# Validation of WEPS Erosion Predictions for Single Wind Events

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## Introduction

The Global Change and Terrestrial Ecosystems Soil Erosion Network (GCTE-SEN) has conducted a model validation exercise for water erosion models (www.nmw.ac.uk/GCTEFocus3/networks/erosion.htm).  Similar to water erosion models, wind erosion models also are widely used to design control practices and to estimate both on-site and  off-site erosion impacts.  But most wind erosion models have not had extensive validation.   Hence, a GCTE-SEN model validation project has been initiated for wind erosion models.  Data on selected storm events collected during the last decade by ARS scientists and various cooperators (Fryrear et al., 1991) were distributed to participating scientists for model validation tests (Zobeck, et al., 2001).  In this study, we compared observed soil loss with simulated soil loss predictions for individual storms using the erosion submodel of the Wind Erosion Prediction System (WEPS), as part of the GCTE-SEN model validation exercise.

The WEPS model is a process-based, daily time-step model that simulates weather, field conditions, and wind erosion on crop lands (Hagen et al., 1995; Wagner, 1996).  The WEPS has a modular structure that includes a daily weather simulator along with an hourly wind speed simulator.   There are five additional submodels in WEPS, and these simulate crop growth, residue decomposition, hydrology, soil status, and management operations.  When wind speed exceeds the threshold for erosion, the erosion submodel simulates erosion on a subhourly basis.

During erosion, the horizontal saltation/creep soil discharge has limited transport capacity, while the horizontal suspension soil discharge has nearly unlimited transport capacity from individual fields.  Hence, the erosion submodel simulates these as separate components of the total erosion for each wind direction (Hagen, Wagner, and Skidmore, 1999).  Based on conservation of mass, the saltation/creep discharge is simulated with two sources (entrainment of loose, mobile soil and entrainment of soil abraded from clods and crust) and three sinks (breakage of saltation/creep to suspension-size, trapping of saltation/creep, and interception by plant stalks).  Similarly, the suspension component is simulated with three sources (entrainment of loose soil, entrainment of material abraded from clods and crust, and breakage from saltation/creep to suspension-size).  Simulating the saltation/creep and suspension components separately, greatly facilitates estimating off-site erosion impacts (Wagner and Hagen, 2001).

## Methods

The experimental sites were 2.5-ha., tilled circular areas located in larger fields that did not erode.  Soil sediment samplers (Fryrear, 1986) were arranged in vertical clusters to sample the horizontal soil discharge of eroding soil between the surface and

one m height.  Thirteen clusters were installed within each circular field.  Six clusters were located at 60-degree intervals on each of two concentric circles with radii of 55 and 87 m.  The remaining cluster was located at the center of the circle along with a meteorological tower, associated weather transducers, and data logger.

The horizontal soil flux (kg m$^{-2}$) from sediment samplers in each cluster was integrated to a height of two m to estimate the horizontal soil discharge (kg m$^{-1}$) at each cluster.  The  wind direction and distance to upwind field boundaries for each cluster were also calculated for each storm event.  In our analyses, we fitted an empirical equation to the point-discharge cluster data to estimate the total soil discharge at 180 m downwind and divided the result by 180 to estimate the observed soil loss per unit area. The empirical equation providing the best least-squares error fit to most of the point-discharge data was

$$q = a + bX^c$$

(1)

where q is the downwind horizontal discharge for a storm (kg m$^{-1}$), X is downwind distance from a nonerodible boundary, and a,b,c, are empirical coefficients.

Wind statistics provided for each daily storm included maximum speed, average speed, and a wind factor (Fryrear, Saleh, and Bilbro, 1998).  These statistics were used to calculate three parameters (scale, shape, and zero intercept) for a Weibull cumulative distribution of daily wind speed.  Using the Weibull distribution, a synthetic distribution of subhourly wind speeds was generated that was symmetric about the daily maximum wind speed.  These data were used to drive the erosion submodel simulations.

This study included data from 46 storms in seven locations in six states (Table 1.)

**Table 1. Test sites and surface soil characteristics**.

| Location | Soil Texture | Sand | Silt | Clay | Organic Matter | Calcium Carbonate | Number of storms |
|---|---|---|---|---|---|---|---|
| | | ------------------ percent ------------------------ | | | | | |
| Eads, CO | Clay loam | 29.3 | 38.6 | 32.1 | 1.6 | 1.0 | 2 |
| Elkhart, KS | Fine, sandy loam | 68.1 | 21.5 | 10.4 | 0.7 | 0.0 | 1 |
| Kennett, MO | Sand | 90.0 | 7.1 | 2.9 | 0.7 | 0.2 | 8 |
| Sidney, NB | Loam | 39.8 | 42.9 | 17.4 | 2.3 | 0.0 | 4 |
| Big Spring,TX | Loamy sand | 83.6 | 8.4 | 8.0 | 0.3 | 0.0 | 24 |
| Mabton, WA | Loamy sand | 82.3 | 12.8 | 4.9 | 0.8 | 0.0 | 5 |
| Prosser, WA | Silt loam | 44.2 | 50.2 | 5.7 | 1.1 | 0.0 | 2 |

# Results and Discussion

The average storm loss from the cluster measurements extrapolated to 180 m downwind was 0.82 kg m$^{-2}$, while the average predicted soil loss was 0.64 kg m$^{-2}$. The maximum differences between observed and predicted loss occurred during large erosion events where the predicted values were frequently less than those observed (Fig. 1). Validation of another model reported a similar response with this data set (Zobeck et al., 2001). Reasons for the differences include the scatter in the cluster data along the wind direction which suggested the initial field surfaces were not always uniform as assumed in the model. There were also uncertainties about some of the input field surface conditions when they were not measured close to the storm dates.

Linear regression of the storm data showed reasonable agreement between predicted and observed (R$^2$ = 0.71) with an intercept greater than zero. However, nonlinear regression using Eq. 1 showed that for storm losses less than 2 kg m$^{-2}$ the predictions were close to the 1:1 line, and the intercept was slightly less than zero.
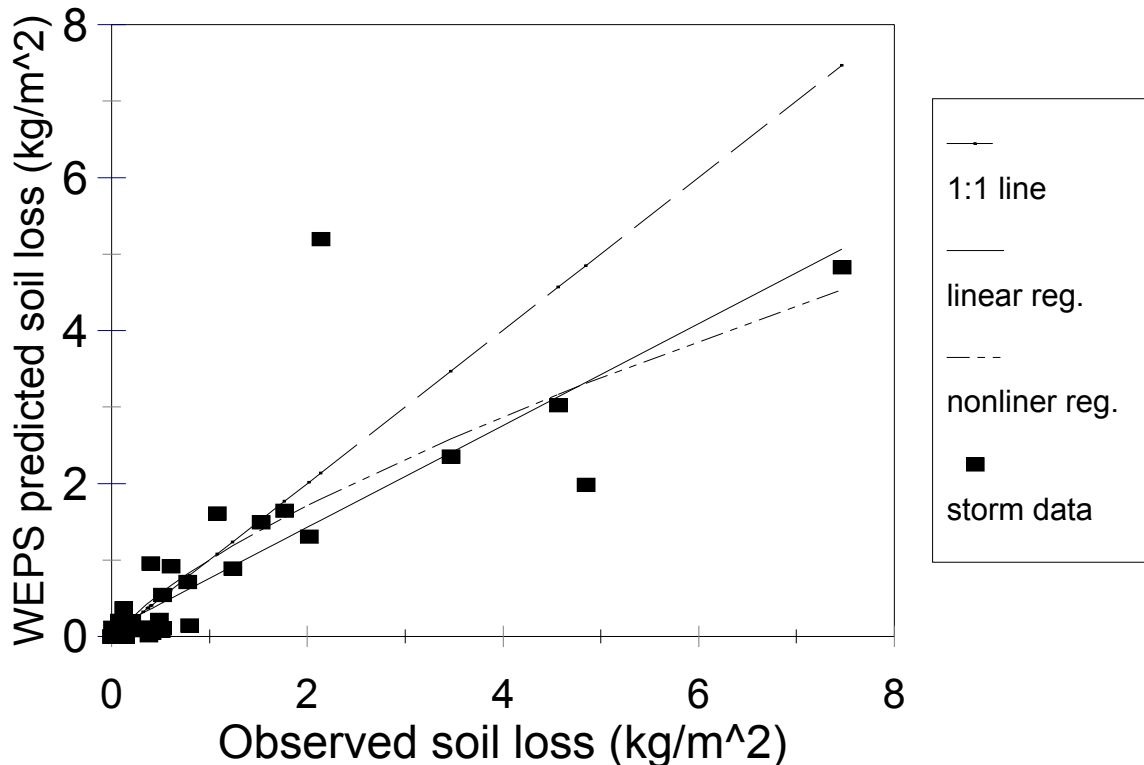


**Figure 1.  Measured versus predicted soil loss for 46 wind erosion storms.**

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